



EPA Region 9

Technical Memorandum: Investigation of Abandoned Wells on Navajo Nation



Prepared for:

**U.S. Environmental
Protection Agency**

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~~Revision No. 1~~

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EPA Contract No. EP-W-15-006

Work Assignment ERG-1-03

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I. Introduction

The United States Environmental Protection Agency (EPA) Region 9 tasked Eastern Research Group, Inc. (ERG) to assist with sampling wells identified as potentially discharging on Navajo Nation lands in New Mexico and Utah. Initially, the State of New Mexico referred the Foshay Well (listed in this report as NM-001), located south of Farmington New Mexico, to the attention of the EPA. After further discussions with the Navajo Nation Environmental Protection Agency (NNEPA) and the State of New Mexico, approximately 48 orphaned well locations were identified. ERG assisted in making observations at each well site, collecting water samples, and preparing and shipping the samples to the EPA Region 9 Lab in Richmond, CA for analysis. The field work took place during the week of July 23-27, 2018. Each of the Navajo Nation Chapter Houses was notified in advance and invited to provide the EPA and NNEPA with information about the wells and potential uses of the water from the wells. Personnel from the Water Resources Program and Underground Injection Control Programs of the NNEPA also participated. The following sections of this report provide a summary of the field activities, including the sample analysis results. Table 1 contains the list provided to EPA of wells to be visited as part of the trip. A map of well locations is provided in Figure 1.

Table [SEQ Table * ARABIC]. Overview of Wells Visited

EPA #	Distance to nearest water body ¹	Nearest Water Body	Latitude	Longitude
NM-001	0.16 miles	Hunter Wash	36.245038	-108.237094
NM-002	0.40 miles	Unnamed tributary to San Juan River	36.946491	-108.914924
NM-003	0.40 miles	Unnamed tributary to San Juan River	36.848559	-108.871965
NM-004	0.35 miles	Unnamed tributary to Sanostee Wash	36.466875	-108.747519
NM-005	0.05 miles	Headwaters Coal Creek	36.566055	-108.686225
NM-006	0.05 miles	Unnamed tributary to Dead Man's Wash	36.663979	-108.703614
NM-007	0.80 miles	Unnamed tributary to Canal Creek	36.949960	-108.861080
NM-008	0.04 miles	Captain Tom Wash	36.338099	-108.606137
NM-009	0.08 Miles	Unnamed tributary to Dead Man's Wash	36.560996	-108.743029
NM-010	0.16 miles	Dead Man's Wash	36.588598	-108.801867
NM-011	0.07 miles	Unnamed tributary to San Juan River (Bob Lee Wash locally)	36.776355	-108.694277
NM-012	0.15 miles	Dead Man's Wash	36.682312	-108.659585
NM-013	0.17 miles	Dead Man's Wash	36.714334	-108.636995
NM-014	0.28 miles	Unnamed tributary to Shiprock Wash	36.756175	-108.811752
NM-015	0.21 miles	Unnamed tributary to Hunter Wash	36.257306	-108.326311
NM-016	0.20 miles	Unnamed tributary to Hunter Wash	36.255950	-108.312392
NM-017	0.48 miles	Unnamed tributary to Pena Blanca Arroyo	36.370172	-108.759744
NM-018	0.01 miles	Unnamed tributary to Tocita Wash	36.396642	-108.735391
NM-019	0.75 miles	Unnamed tributary to Coal Creek	36.60439	-108.638977
NM-020	0.16 miles	Chaco River	36.660928	-108.531515

Commented [LR1]: Distance to waterbody appears to be off if the photo, which shows the well literally in standing water, is correct

¹ Findings of federal jurisdiction or compliance with any particular law or permit are beyond the scope of this technical memo, and no such findings should be inferred by the occasional use of descriptive terms (such as "waterbody" or "dry wash").

EPA #	Distance to nearest water body ¹	Nearest Water Body	Latitude	Longitude
NM-021	0.10 miles	Many Devils Wash	36.701599	-108.718738
NM-022	0.44 miles	Unnamed tributary to Shiprock Wash	36.760366	-108.814590
NM-023	0.02 miles	Unnamed tributary to Shiprock Wash	36.750998	-108.832756
NM-024	0.87 miles	Unnamed tributary to Shiprock Wash	36.812636	-108.862554
NM-025	0.09 miles	Unnamed tributary to Beclabito Wash	36.874828	-108.939572
NM-026	0.37 miles	Unnamed Tributary to Indian Creek	35.907263	-108.196736
NM-027	0.30 miles	Unnamed tributary to Little Shiprock Wash	36.755327	-108.895413
NM-028	0.15 miles	Unnamed tributary to Shiprock Wash	36.800610	-108.893418
NM-029*	0.25 miles	Middle Sanostee Wash	36.424442	-108.869999
NM-029A*	0.01 miles	50 feet to a pond	36.426250	-108.891300
NM-030	0 miles	Headwaters of unnamed tributary to Sheep Springs Wash	36.188230	-108.614489
UT-001	0.10 miles	Montezuma Creek	37.305228	-109.301357
UT-002	0.66 miles	San Juan River	37.201927	-109.185284
UT-003	0.67 miles	Unnamed tributary to Desert Creek	37.242245	-109.341598
UT-004	0.25 miles	Unnamed tributary to McElmo Creek	37.227680	-109.118423
UT-005	0.03 miles	Unnamed tributary to San Juan River	37.188754	-109.158535
UT-006	0.42 miles	Unnamed tributary to San Juan River	37.249027	-109.180991
UT-007	0.10 miles	Montezuma Creek	37.313337	-109.297489
UT-008	0.23 miles	Montezuma Creek	37.302587	-109.301409
UT-009	0.64 miles	Unnamed tributary to Montezuma Creek	37.296995	-109.313719
UT-010	0.34 miles	Unnamed tributary to Sahgzie Creek	37.179196	-109.284019
UT-011	0.36 miles	Unnamed tributary to McElmo Creek	37.234262	-109.120296
UT-012	0.03 miles	Lone Wash	37.163981	-109.299101
UT-013	0.45 miles	Unnamed tributary to San Juan River	37.111667	-109.076389
UT-014	0.31 miles	McCracken Wash	37.336401	-109.392383
UT-015	0.21 miles	McCracken Wash	37.337881	-109.384476
UT-016	0.02 miles	McCracken Wash	37.341654	-109.386066
UT-017	0.02 miles	West Fork Allen Canyon	37.285763	-109.242444
UT-018	0.13 miles	San Juan River	37.214646	-109.185307

Commented [LR2]: In the photos (Appendix B), there is a well shown as NM-23A. That designation does not appear here or elsewhere.

*Coordinates provided for NM-029 initially identified a different location. Wells were discovered in two other locations, which were listed as NM-029 and NM-029A.

II. Background

As mentioned in Section I, the EPA learned from NNEPA there were approximately 48 orphaned wells located on Navajo Nation lands that may be producing water at the surface. Most of the wells were drilled for oil and natural gas exploration decades ago and none are currently producing hydrocarbons. An additional well was added during field activities (NM-029A) after it was observed discharging near NM-029, creating a total of 49 wells visited. All wells are located on the Navajo Nation reservation and would otherwise be located within the state lines of New Mexico and Utah. Figure 1 shows the exact well locations and Navajo Nation Chapter Houses. Some of the wells are in populated areas, but most are in remote locations.

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- the Navajo Nation Division of Natural Resources,
- the US Bureau of Land Management (Department of the Interior),
- the US Bureau of Indian Affairs (Department of the Interior),
- the New Mexico Oil Conservation Division (New Mexico Energy, Minerals and Natural Resources Department – State of New Mexico),
- the New Mexico Environment Department (State of New Mexico),
- the New Mexico State Land Office (State of New Mexico),
- the Utah Department of Natural Resources (State of Utah).

Each of the Navajo Chapter Houses was notified and invited to provide the EPA and NNEPA with information about the wells and potential uses of the water from the wells.



Photograph 1. The Foshay well (NM-001), located approximately 55 miles northeast of Gallup, NM.

III. History of Wells

The history of each well was researched by the EPA through consultation with the tribal, federal, and state agencies. Table 2 provides a summary of the information compiled, including the date of well completion, depth, and any additional information gathered. This information was provided by the EPA and NNEPA and condensed to provide relevant historic information. If information was not available for a given category it was left blank. For thirteen of the discharging wells, no historic information was found, so they were not included in Table 2.

Table [SEQ Table * ARABIC]. Summary of Known Well History

EPA #	Well Completed	Recorded Depth (ft)	Additional Information
NM-001	01/22/1972	9,803	Plugged to a depth of 4,630 feet in early 1972; re-entered in summer of 1974 and turned over to Bureau of Land Management as livestock water supply well in 1980; via a land swap, turned over to the Navajo Nation with 1984 Navajo-Hopi Settlement Act.
NM-002	12/05/1962	1,885	Plugged 01/10/1963
NM-003	11/21/1977	2,000	Drilled to the Morrison formation
NM-004	05/28/1967	796	Drilled to the Dakota formation
NM-005	05/18/1964	778	Drilled to the Gallup formation; original operator was Lonnie Kraemer; plugged 05/18/1964
NM-006	07/24/1968	7,327	Plugged 08/26/1968
NM-007	11/15/1962	7,550	Plugged 11/21/62
NM-008	05/21/1962	4,335	Plugged back to depth of 3,660 feet; Drilled to the Gallup formation; turned over to "Navajo Indian Agency" in May 1962
NM-009	08/03/1960	1,992	Drilled to the Morrison formation
NM-010	12/04/1934	415	
NM-011	02/07/1961	1,850	Drilled to the Morrison formation; located next to Shiprock fairgrounds; flows into Bob Lee Wash and then onto San Juan River floodplain; Department of Energy ID is well 648; Water quality data available from DOE
NM-012	11/03/1977	2,520	Drilled to the Morrison formation
NM-013	11/02/1977	2,300	
NM-014	02/11/1924		
NM-015	08/18/1973	5,250	
NM-019			Drilled to the Dakota formation; assumed by Navajo Nation via letter in 1999
NM-022	03/25/1927	2,013	Drilled to the Morrison formation
NM-027	07/16/1979	1,721	
NM-028	07/19/1979	1,681	
NM-030	01/20/1966	1,826	Identified by Bernice Benally, whose family uses it as a domestic water source
UT-002	02/15/1962		Unclear if this is the P&A Giant well or if the P&A Giant well is just west of this location;
UT-003	02/12/1956	612	
UT-004	12/15/1964	5,854	
UT-005			Listed as a hand pump well
UT-006	02/18/1958	1,098	Mobil WSW 22 (lab results available); historic docs indicate water forms small ponds
UT-007	04/22/1974	5,590	
UT-008		230	sampled by NNEPA using funds from Resolute Natural Resources in 2005; historic docs state "flows from open casing at ground level"
UT-009			historic docs state " flows from open casing 4ft above land surface"
UT-010	07/31/1992	600	former oil test plugged in 1992 (USGS); historic docs state "water used for domestic and stock purposes"
UT-011	12/01/1958	720	abandoned windmill site (USGS)
UT-012	03/03/1960	5,686	historic docs state "former oil test; water flows from above 1,325ft"
UT-013	10/24/1960	1,880	historic doc states "Water flows from ground near sealed casing; initial well drilled to 1,880 ft and used as water well for deeper adjacent well"

EPA #	Well Completed	Recorded Depth (ft)	Additional Information
UT-014	07/30/1957	5,597	historic doc state "former oil test; water flows from above 964ft"
UT-017		300	
UT-018	07/01/1942		Near the old Aneth chapter house; was dynamited in attempt to plug

IV. Field Work

The field activities were conducted by three teams, each comprised of three or four staff from the EPA, ERG and the NNEPA. Each team visited approximately one third of the 49 wells. Field observations were collected on an identical form at each well location. The date/time sampled, site description, evidence of public usage/exposure, livestock use, and other general observations were described at each site. Coordinates for each location were collected using a handheld Global Positioning System (GPS), and were recorded on the field sheets. A summary of observations made at each well is provided in Appendix A. Photos are included to support field observations at wells identified to be used as human drinking water sources, livestock use, and for other general points of interest. Photographs of each location can be found in Appendix B.

Temperature, specific conductance, and pH were collected using a multimeter. Multimeters were calibrated each day prior to use. Temperature is shown below in degrees Celsius, pH in standard units, and specific conductance in microSiemens per centimeter ($\mu\text{S}/\text{cm}$). Flow was measured using a flowmeter where a channel was present or by using a five-gallon bucket and a stopwatch when a spigot was present. Flow could not be measured or collected at sites where:

- flow was occurring below the surface of standing water,
- flow emanated from multiple points in such a way that they could not be separately collected and added together, or
- when seep flows were too low to measure where encountered.

Each team made onsite measurements of air emissions and radiation using a Multirae gas monitor and a Ludlum Geiger counter. No notable measurements outside of ambient background levels were observed. Therefore, results of these measurements are not included in this technical memo.

In addition, the team collected water samples, if able, for analysis at the EPA's laboratory in Richmond, CA. All sampling activities were performed in accordance with the Navajo Nation Discharging Wells Sampling Analysis Plan, which was reviewed by the EPA Quality Assurance Program Manager.



Photograph 2: Example of a well (NM-003) where well water was re-routed. The sampling team interviewed a local land owner who stated they used the water for drinking water and for livestock.

V. Analytical Results

Water samples were collected from 46 of the 49 wells and did not include the well sites UT-004, UT-014, and UT-017, which lacked sufficient flow to collect a sample. The samples were sent to the EPA Region 9 Laboratory and were analyzed for the following constituents:

- Total Metals,
- Volatile Organic Compounds,
- Petroleum Hydrocarbons,
- Semivolatile Organic Compounds, and
- Conventional Chemistry Parameters.

For the full list of constituents and complete analytical results, refer to Appendix C.

The analytical results were compared with EPA and NNEPA Drinking Water Maximum Contaminant Levels (MCLs), the EPA Secondary Drinking Water Regulations, Navajo Nation Water Quality Standards (WQS) for Primary Human Contact, Agricultural Water Supply, and Livestock Use, Ambient Water Quality Guidelines for Sulphate Technical Appendix Update (British Columbia Ministry of Environment, April 2013), and Ambient Water Quality Criteria for Chloride (EPA, 1998). Both the Ambient Water Quality Guidelines for Sulphate and the Ambient Water Quality Criteria for Chloride are guidance for chronic toxicity for aquatic life. The results were compared to the above benchmarks and guidelines solely as indicators for potential threats to human health or designated uses that could warrant further investigation. Exceedances of these benchmarks and guidelines were detected in 38 wells, listed below,

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for lead, arsenic, sulfate, benzene, and chloride. Table 3, below, shows the lab results for these analytes compared against the benchmarks and guidelines.

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- Orange text indicates an exceedance of EPA and NNEPA Drinking Water MCLs. For lead, arsenic, and benzene, the Navajo Nation WQS for domestic water supply are equivalent to the EPA drinking water MCLs.
- Red Text indicates an exceedance of the Navajo Nation WQS for primary human contact.
- Navajo Nation Water Quality Standards for Agricultural Water Supply and Livestock Use are shown in brown text for reference, although no exceedances of these standards were detected.
- Green text indicates an exceedance of either Ambient Water Quality Guidelines for Sulphate or Ambient Water Quality Criteria for Chloride.
- Empty cells in Water Quality Standards indicate that there is no standard associated with the constituent.

The full laboratory reports containing all sample results are included in Appendix C.

Table [SEQ Table * ARABIC]. Water Quality Standard Exceedances Sampling Results

		Lead (ug/L)	Arsenic (ug/L)	Sulfate (mg/L)	Benzene (ug/L)	Chloride (mg/L)
Water Quality Standards and	EPA Drinking Water MCL / Navajo Nation WQS (NNWQS) for Domestic Water Supply (Identical)	15*	10		5	
	EPA Secondary Drinking Water Regulations			250		250
	NNWQS for Primary Human Contact		30		93	
	NNWQS for Livestock	100	200			
	NNWQS for Agricultural Water Supply	10000	2000			
	Ambient Water Quality Criteria (Chloride, EPA, 1998) or Guidelines (Sulphate) for Aquatic Life			429		230
Well Sample Results	NM-001	ND	5.9	5800	ND	500
	NM-002	ND	16	1300	0.7	510
	NM-003**	ND	22	31	0.6	11
	NM-004**	ND	ND	130	0.4	14
	NM-005	ND	ND	1500	ND	170
	NM-006	ND	0.54	3200	16	580
	NM-007	ND	4.2	2800	0.4	1100
	NM-008	ND	ND	2100	ND	220
	NM-009**	ND	3.6	55	ND	4
	NM-010	ND	ND	460	ND	20
	NM-011	ND	0.57	2000	0.8	54
	NM-012	ND	1.1	1900	16	83
	NM-013	ND	1.5	2000	7.9	99
	NM-014	ND	2.4	630	ND	3400
	NM-015	ND	5	400	ND	17

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	Lead (ug/L)	Arsenic (ug/L)	Sulfate (mg/L)	Benzene (ug/L)	Chloride (mg/L)
NM-016	ND	5.1	400	ND	17
NM-017**	0.59	1.8	130	ND	39
NM-018	10	13	390	ND	65
NM-019	ND	ND	2500	ND	200
NM-020	ND	0.35	1600	ND	310
NM-021	15***	10	810	ND	88
NM-022	15***	6.2	1700	ND	760
NM-023	ND	5.5	1600	ND	740
NM-024	ND	1.5	1300	ND	98
NM-025	3.6	3.2	1600	ND	56
NM-026	ND	ND	1000	2.3	1600
NM-027	ND	3.1	7	ND	1.2
NM-028	ND	4.4	18	ND	3.1
NM-029**	ND	2.1	24	ND	2.6
NM-029A**	ND	1.1	4	ND	3.2
NM-030**	ND	ND	27	ND	4.1
UT-001	ND	25	280	ND	680
UT-002	0.59	21	3800	ND	1300
UT-003	ND	42	2600	ND	1400
UT-004	no sample				
UT-005	ND	4.1	1000	ND	100
UT-006	2.4	55	770	ND	700
UT-007	ND	11	43	ND	2.8
UT-008	ND	10	310	ND	170
UT-009	ND	32	230	ND	540
UT-010**	ND	15	230	ND	78
UT-011	ND	11	780	ND	150
UT-012	ND	22	430	ND	130
UT-013	ND	8.4	1100	ND	86
UT-014	no sample				
UT-015	ND	15	69	ND	16
UT-016	ND	12	740	ND	350
UT-017	no sample				
UT-018	ND	13	1600	ND	3900

ND= Non-Detect; "no sample" indicates the well was not sampled.

*The 15 µg/L value for lead is an Action Level, not an enforceable legal limit.

**Well was identified as used by people for drinking water during field activities.

***Sample result is equal to the EPA and NNEPA Drinking Water Action Level for Lead of 15 µg/L.

Lead: Although none of the samples showed an exceedance of the water quality standards for lead, samples from two wells (NM-021 and NM-022) contained concentrations of lead *equal to* the numeric Action Level established by the EPA and NNEPA Drinking Water Action Level for Lead, and the Navajo Nation WQS for primary human contact (all three standards have the same numeric limit for lead). Neither of these two wells were identified to be likely drinking water sources during field activities based on observations and discussions with local residents. For more information about human exposure to lead in drinking water, refer to the EPA Office of Water's webpage on Basic Information about Lead in Drinking Water—([HYPERLINK "https://www.epa.gov/ground-water-and-drinking-water/basic-information-about-lead-drinking-water%23health"])

Arsenic: 15 of the 46 samples contained exceedances of the numeric limit for arsenic established by the EPA and NNEPA Drinking Water MCLs for arsenic. Three of these samples (wells UT-003, UT-006, and UT-009) contained concentrations of arsenic that also exceeded the numeric limit established by the Navajo Nation WQS for primary human contact. For more information about human exposure to arsenic in drinking water, refer to the [HYPERLINK "https://nepis.epa.gov/Exe/ZyPdf.cgi?Dockey=20001XXC.txt"] ([HYPERLINK "https://nepis.epa.gov/Exe/ZyPdf.cgi?Dockey=20001XXC.txt"]).

Sulfate: 33 of the 46 samples contained exceedances of the numeric limit for sulfate established by the EPA secondary drinking water regulations. For more information about human exposure to sulfate in drinking water, refer to the EPA Office of Water's webpage on Secondary Drinking Water Standards: Guidance for Nuisance Chemicals [HYPERLINK "https://pgeenv.sharepoint.com/clients/OCE/30003_010_26_Navajo%20Oil%20Wells/Working/Report/(https://www.epa.gov/dwstandardsregulations/secondary-drinking-water-standards-guidance- nuisance-chemicals)"].

Benzene: 3 of the 46 samples contained exceedances of the numeric limit for benzene established by the EPA and NNEPA Drinking Water MCLs for benzene. These wells are NM-006, NM-012, and NM-013, none of which were identified by the field teams as likely sources of human drinking water. For more information about human exposure to benzene in drinking water, refer to the EPA Office of Water's Benzene Fact Sheet ([HYPERLINK "https://safewater.zendesk.com/hc/en-us/sections/202346497"]).

Chloride: 16 of the 46 samples contained exceedances of the numeric limit for chloride established by the EPA secondary drinking water regulations. For more information about human exposure to lead in drinking water, refer to the EPA Office of Water's webpage on Secondary Drinking Water Standards: Guidance for Nuisance Chemicals [HYPERLINK "https://pgeenv.sharepoint.com/clients/OCE/30003_010_26_Navajo%20Oil%20Wells/Working/Report/(https://www.epa.gov/dwstandardsregulations/secondary-drinking-water-standards-guidance- nuisance-chemicals)"].

Appendix A
Field Summaries of Each Well
Navajo Nation Wells
Sample Dates: 7/23/2018-7/27/2018

Appendix B
Photographs of Each Well Location
Navajo Nation Wells
Sample Dates: 7/23/2018-7/27/2018

Appendix C
Laboratory Analytical Results
Navajo Nation Wells
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